INSTRUCTION MANUAL

MODEL 306TDL

TRACKING
WAVE AND SPECTRUM ANALYZER

FOR SERIAL NO._____

Scientific-Atlanta

New Jersey Division

Specialists in Electronic Instrumentation

Randolph Park West, Randolph Township, New Jersey 07801
Telephone: (201) 361-3100 TWX 710-987-7946

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CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Scientific-Atlanta, Inc., New Jersey Division warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electronic tubes and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misadjustments, misuse, or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

Calibration checks of this instrument can easily be made in accordance with the instruction manual. Routine adjustments **should never** be attempted. If, however, the instrument has been damaged and requires recalibration or alignment, explicit calibration procedures as defined in the instruction manual **must** be followed.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory. If requested an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

The instruments should be packed in their original containers, or in a strong exterior container and surrounded by two inches of shock absorbing material.

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A. DESCRIPTION

The Model 306TDL is a multi-purpose instrument. It is not only useful as a precision wave analyzer for harmonic measurements and Fourier analysis of complex signals, but its five selectable flat-top bandwidths make it ideally suited for spectral density analysis of random signals.

The Model 306TDL features electronic tuning, using a stable voltage controlled oscillator and offers a five digit display (i.e. resolution to 1 Hz). A six position MODE switch controls the tuning functions. In the MODE OFF position the instrument acts as a normal, manually tuned wave analyzer. In the AFC position the Analyzer will track a drifting signal and follow it over a limited frequency range determined by the bandwidth. In the TRACK position, the instrument will lock onto a signal and follow it over the whole or discrete portions of the tuning range. In the SWEEP position, the Analyzer will start at the frequency to which the unit is tuned, and scan upward in frequency over the whole or discrete portions of the tuning range, as determined by a sweep increment switch. In the SEARCH & TRACK position, the instrument will scan as in the SWEEP position, until it finds a signal, whereupon it will lock onto the signal and track it as in the TRACK mode. If the signal disappears, the analyzer will continue to scan automatically until the original signal or a new one is found. Since the sweep time, sweep increment, averaging time, and bandwidth are interdependent, a red light will appear if the various switches are set to a combination which would lead to erroneous results. With the MODE switch in the EXT position, the instrument may be tuned by an external DC voltage.

Two or more Model 306TDLs may be connected together without modification to form a multi-channel, master-slave analyzer system suitable for mechanical impedance and transfer function analysis.

A multiplicity of outputs greatly increases the versatility of the Model 306TDL. When used with an X-Y plotter it can automatically make an amplitude vs. frequency or amplitude-phase plot of the characteristics of an electronic or electromechanical system. When used with an oscilloscope, X-Y plotter, or strip-chart recorder, it becomes a spectrum analyzer whose center frequency, sweep width and resolution can all be varied over wide limits. Averaging time, bandwidth, and sweep speed can be selected for optimum results in random signal analysis.

B. SPECIFICATIONS

FREQUENCY RANGE:	10 to 50,000 Hz
READOUT ACCURACY:	±0.01% or 1 Hz
SELECTIVITY:	Five pass bands, 10Hz, 30Hz, 100Hz, 300Hz, and 1000Hz at 3dB down, selectable by a front panel switch. The filter design is maximally flat (Butterworth approximation) with 24dB roll-off.
VOLTAGE RANGE:	30uV to 100 volts full scale in 10dB steps; also a variable gain control of 20dB.
VOLTAGE ACCURACY:	±5% of full scale reading.
LOG RANGE:	0dB to -70dB
LOG ACCURACY:	±2dB
DYNAMIC RANGE:	Greater than 70dB for Fourier analysis; greater than 40dB for random signal analysis.
INPUT IMPEDANCE:	1 Megohm
METER AVERAGING TIMES:	Approximately 0.01, 0.1, 1, and 10 seconds, switch selectable.
TUNING MODES:	Manual, AFC, Track, Sweep, Search and Track and External.
AFC RANGE:	Approximately 4 bandwidths.
TRACK INCREMENT:	0.5 1 , 5 , 10 , or 50KHz from tuned frequency, switch selectable.

SWEEP TIME:	0.5, 5 , 50 , or 500 seconds, switch selectable.
SWEEP RANGE:	0.5 , 1 , 5 , 10 or 50 Khz, switch selectable.
SWEEP MODES:	Single or Automatic, with reset.
EXTERNAL MODE:	±5 volts for ± sweep range from tuned frequency.

ANALOG OUTPUTS:

SWEEP ANALOG:	0 to +5 volts for any sweep increment; available at front panel and rear connector.
METER ANALOG:	0 to +1 volt proportional to meter deflection; available at front panel and rear connector.
B F O:	Sine wave output at the frequency to which the instrument is tuned. Variable to approximately 1 volt RMS into 600 ohms.
RESTORED:	A replica of the input signal, filtered in accordance with tuning and bandwidth. Variable to approximately 1v RMS into 600 ohms.

The following are available at rear connector only.

FREQUENCY ANALOG:	A positive DC voltage where 1 millivolt equals 1Hz.
PHASE ANALOG:	In-phase and quadrature components, each equal to approximately 1 volt peak-to-peak for full scale deflection.
MASTER SLAVE CONNECTIONS:	100KHz crystal controlled and 100 to 150Hz variable.
POWER INPUT:	117/234 VAC, 50 to 400Hz, 12 Watts.
DIMENSIONS:	16½" Wide x 8" High x 12" Deep. (Includes feet and handles)
WEIGHT:	20 lbs.

A thorough understanding of an instrument and its principles of operation greatly enhance its usefulness. The Model 306TDL Wave and Spectrum Analyzer is a precision instrument capable of performing accurate signal analysis. For the most effective application of this equipment we strongly recommend that the prospective operator read Section 3, the Theory of Operation, before using the instrument.

A study of both the block diagram and the following description, along with the panel markings, will help to familiarize the operator with the functions of the various panel controls.

A. DESCRIPTION OF CONTROLS, INPUTS AND OUTPUTS

1. MANUAL TUNING - The COARSE and FINE controls can each change the frequency of the voltage controlled oscillator (VCO), thereby tuning the instrument. The controls differ in both range and resolution, but are alike in that each control precisely converts angular motion to a change in frequency of the VCO.

2. AUTOMATIC TUNING MODES - In addition to manual control of the VCO, provision has been made to electronically tune it in any of several modes as selected by the MODE switch.

   a. In the AFC mode, the instrument will follow a signal which moves no more than approximately four instrument bandwidths.

   b. In the TRACK mode, the instrument will track a moving signal over selectable increments of the instrument tuning range. Increment width is selected by means of the RANGE control.

   c. In the SWEEP mode, the operator may scan in its entirety or incrementally, the spectrum from 10Hz to 50KHz. The increment width again is selectable by means of the RANGE control. The scan time per range increment is selectable by means of the TIME control (0.5 to 500 seconds).

   d. The SEARCH AND TRACK mode is a combination of the SWEEP and the TRACK mode. One may electronically scan the spectrum or portions thereof, as in the SWEEP mode. When a signal of given amplitude, as determined by the TRACKING THRESHOLD is found, the instrument will automatically switch to the TRACK mode and track the signal. If the signal moves beyond the range increment or drops below the pre-set threshold, the instrument will revert to the scanning mode until it once again finds a signal.

e. Provision has been made for the operator to externally program the electronically tuned VCO by means of a connector at the rear of the instrument. This function is accomplished with the MODE switch in the EXT position.

f. The RESET/SINGLE/AUTO switch provides for single or repetitive scanning in the SWEEP or SEARCH and TRACK modes of operation.

The RESET is an inhibit position for the AFC, TRACK, SWEEP, or SEARCH AND TRACK modes. An analog voltage is available at the SWEEP ANALOG jack for operating oscilloscopes, recorders, etc.

3. MASTER/SLAVE operation

This mode of operation is controlled by a switch at the rear of the Model 306TDL. For normal or master operation, the MASTER/SLAVE switch is left in the MASTER (M) position. The switch is thrown to the SLAVE (S) position if one wishes to drive one or more 306TDLs as slave units, subordinate to a 306TDL designated as MASTER. For instance, if one wishes to make simultaneous electronic measurements of two or more points related to phase and amplitude by some complex transfer function, one may use two or more 306TDL Wave Analyzers as slaved units, driven by the master unit.

4. SENSITIVITY

The METER MULTIPLIER, VARIABLE GAIN and MILLIVOLTS FULL SCALE controls set the instrument's sensitivity and provide for a combined range of 130 dB. The METER MULTIPLIER and VARIABLE GAIN controls are associated with the input circuits and serve to adjust the input signal level to the correct value for analysis. The MILLIVOLTS FULL SCALE switch is, in essence, a range switch for the voltmeter. The sensitivity of the Analyzer is increased in 10dB increments as this control is rotated counter-clockwise. For absolute amplitude measurements, the 20dB VARIABLE GAIN control should be rotated clockwise to the CALIBRATED position; the meter will then read directly in millivolts times the METER MULTIPLIER.

In the LOG position of the MILLIVOLTS FULL SCALE switch, the instrument sensitivity is 1000 mv times the METER MULTIPLIER setting. The dynamic range in this mode of operation is 70dB, which can be read on the lower DB scale provided.

5. SELECTIVITY

The overall passband of the system is controlled by the BANDWIDTH switch and may be set to 10, 30, 100, 300, or 1000Hz.

6. METERING

The METER T.C. switch provides for the selection of meter averaging times. The operator will find it helpful in that the averaging time can be changed by the same ratio as the system bandwidth, namely, 10:1. The selectable averaging time is of particular usefulness in the measurement of noisy signals.

The METER ZERO controls provide a means of periodically balancing critically matched circuits which are subject to change with time and temperature. Circuit unbalance is indicated by a finite meter reading with no signal applied and should be "zeroed out" for correct operation.

For recording purposes, the METER ANALOG voltage is made available at both a jack on the front panel and at a connector at the rear of the instrument.

7. BFO AND RESTORED

The BFO is a sine wave equal to the frequency to which the instrument is tuned, whereas the RESTORED signal is equal to the input signal after it has been passed through the selected filter and therefore is only available when the instrument is tuned to an input signal.

B. INITIAL OPERATION

1. Connect the instrument to a suitable source of power. Refer to the plate located near the power cord for the voltage and frequency for which the instrument is wired.

2. Allow at least 10 minutes for the instrument to stabilize before making any adjustments.

3. Zero the meter as follows:

   a. Set the frequency such that the instrument is tuned neither to an incoming signal nor the zero frequency carrier.

b. Turn the MILLIVOLTS switch counterclockwise to progressively more sensitive ranges. As the sensitivity of the instrument is increased, a residual voltage may be discernible. Alternately adjust the METER ZERO controls for a minimum meter reading, adjusting for the best possible null on the most sensitive range. (This should be less than 2% of full scale).

NOTE: The instrument is now ready for operation. However, for best performance, the above procedure should be repeated periodically.

C. MANUAL OPERATION

The actual procedure for instrument operation depends on the test to be performed. A typical example of manual operation is as follows:

A one volt, 1KHz signal is to be analyzed for harmonic distortion.

1. Set BANDWIDTH switch to 100Hz.
2. Set MILLIVOLTS FULL SCALE switch to 1000.
3. Set METER MULTIPLIER switch to X1.
4. Turn the VARIABLE GAIN control clockwise to CALIBRATE position.
5. Select METER T.C. of .1 sec.
6. Connect the signal to the INPUT.
7. Tune the FREQUENCY COARSE control to the 1KHz signal.

Now that both the amplitude and frequency of the fundamental signal are known, measure the second harmonic content by tuning the frequency to twice the fundamental frequency (approximately 2 KHz). Rotate the MILLIVOLTS FULL SCALE switch counterclockwise until the meter reads up scale. This measure of the second harmonic may now be related to the fundamental signal by expressing its magnitude in percentage of, or decibels below one volt. Similarly, by successively tuning to 3,4 and 5 KHz, the magnitude of the third, fourth and fifth harmonics of the fundamental may be measured.

D. AUTOMATIC MODES

1. AFC

a. Adjust the instrument as in steps 1 thru 7 of MANUAL OPERATION.

b. Set the SINGLE/AUTO/RESET switch to RESET position (effective AFC inhibit).

c. Set MODE switch to AFC position.

d. When SINGLE/AUTO/RESET switch is switched to either SINGLE or AUTO, the AFC becomes effective.

The AFC will hold for approximately four times the BANDWIDTH switch setting.

2. TRACK

a. With MODE switch in OFF position, tune the instrument to a desired signal component as in the MANUAL OPERATION Section.

b. Set RESET/SINGLE/AUTO switch to RESET position.

c. Use the RANGE switch to select the frequency range over which it is desired to track the signal.

d. Choose the bandwidth and meter time constant as required.

NOTE: In the interest of providing maximum versatility, the bandwidth, sweep, and averaging time controls have not been interlocked such as to always provide maximum accuracy. The operator must therefore consider with care his choice of setting.

The field of waveform and spectrum analysis is both broad and complex. There are, however, several excellent texts and articles published on the subject and therefore no attempt will be made in this short manual to cover it thoroughly. Instead, listed below are a number of basic formulae and notes intended merely to serve as a guide to effective use of the equipment.

(1) Sweep or Track rate (Hz) = $\frac{\text{Sweep or Track RANGE}}{\text{Sweep or Track TIME}}$

or $SR = \frac{W}{T}$

(2) The maximum SR, with regard to bandwidth, should not exceed the following formula:

$$SR_{(Max)} = \left[\frac{BW}{2}\right]^2$$

This refers to the analysis speed limitation imposed by the system bandwidth and can be violated only at the expense of accuracy.

(3) The averaging time (METER T.C.) should be selected according to the accuracy requirements of the particular test. In the case of pure random noise, the statistical error (e) due to finite filter bandwidth and averaging time may be estimated by:

$$e = \left[\frac{1}{8BW \quad (TC)}\right]^{\frac{1}{2}}$$

where e = Probable error

BW = Effective filter bandwidth

TC = Meter time constant

(4) Set the sweep TIME switch to the shortest time which does not light the red indicator lamp.

(5) Switch the RESET/SINGLE/AUTO switch to AUTO. The instrument will now track the signal over the range ± (Δf) from the manually set frequency (f).

3. SWEEP

a. Tune to the frequency at which the sweep is to start.

b. Select the bandwidth and metering time constant as required.

c. Select the SWEEP width; 0.5 , 1 , 5 , or 10 or 50 KHz.

d. Set the SWEEP time; 0.5, 5 , 50 , 500 seconds (See 2.,d.)

e. To initiate the SWEEP, set the RESET/SINGLE/ AUTO switch first to RESET then back to either the AUTO or SINGLE position.

(1) AUTO - Instrument will continuously scan the selected frequency range.

(2) SINGLE - Instrument will make one scan, stopping at the top of the selected frequency range. The unit will then maintain this tuning until manually detuned or reset.

4. SEARCH AND TRACK

a. The instrument is adjusted as in the SWEEP mode of operation with the exception that when it finds a signal, it will automatically switch to a track mode of operation.

Note that, as in the SWEEP mode, the instrument scans upward through a given range increment, whereas once a signal has been found, the instrument will track both + and - from dial setting by that same range increment.

5. EXTERNAL

In this mode of operation a ±5V control voltage applied to the EXTERNAL input, at the rear connector of the instrument, will electronically tune the instrument by the RANGE increment ($\triangle$f) selected, ± from the tuned frequency (f).

ADDENDUM TO 306TDL MANUAL

SECTION 2 - OPERATION

E. MASTER/SLAVE OPERATION

1. PURPOSE

Two 306TDLs may be connected together in such a way that the center frequency of the bandpass filters of both analyzers is controlled by one of the units called the MASTER. This mode of operation facilitates transfer function measurements, giving both amplitude and phase information.

2. CONNECTIONS

A. Use coaxial cable to connect pins 1, 2 and 4 of J108 on the MASTER unit to pins 1, 2 and 4, respectively, on J108 of the SLAVE unit. At each connector tie the shields to pin 8. Do not exceed four (4) feet in the length of each cable.

B. On the 306TDL which is to act as the MASTER unit, set S109 (slide switch located on the rear panel adjacent to J108) to the M position.

C. On the 306TDL which is to act as the SLAVE unit, set S109 to the S position.

D. Adjust the METER ZERO controls of each unit as described in paragraph B, INITIAL OPERATION.

3. AMPLITUDE MEASUREMENTS

The operation of each analyzer remains basically the same as with single unit operation; the control of bandwidth, attenuators, and meter TC is unaffected by the M/S connection. The frequency of each analyzer is controlled simultaneously by the MASTER.

4. PHASE MEASUREMENTS

Phase shift between two voltages of the same frequency may be determined using the two 306TDLs in the M/S connection. This is done by monitoring the phase shift between the CARRIER OUT (J101; CARRIER OUT to pin 8, ground to pin 16) signals of the two units. The CARRIER OUT has a frequency of 100 kHz and the amplitude is proportional to the analyzer meter deflection, being approximately 3 volts p-p at full scale. The phase shift between the two CARRIER OUT signals may be monitored with an oscilloscope or phasemeter.

In using the M/S connection for phase shift measurements, use the same bandwidth in both units, and keep the signals being measured in the center of the instruments bandpass filters. It may be helpful to

use the TRACK or AFC mode for signals with varying frequencies.

Any two 306TDLs connected for M/S operation will show a phase shift offset when the same signal is applied to both inputs. This offset must be measured and then subtracted from all phase readings made with the two analyzers to get the true phase shift between unknown signals.

A. THEORY OF OPERATION

The Model 306TDL is basically a dual conversion hetrodyne receiver having a 100KHz first IF and a Zero center frequency second IF.

The variable oscillator is a voltage controlled oscillator producing an output variable from 100 to 150KHz. It is extremely stable and linear, and enables the instrument to be electronically swept over its whole range by an internal ramp in the SWEEP mode. In the AFC, TRACK, and SEARCH & TRACK modes a phase detector controls the variable oscillator enabling the instrument to track a moving signal.

Referring to the Block Diagram, the incoming signal goes through a step attenuator and amplifier into a low pass filter which removes frequencies above 50KHz. The signal is then mixed with the output of the 100 to 150KHz variable oscillator. The difference frequency is passed through the 100KHz first IF to a pair of second modulators. The two second modulators are driven 90° out of phase by a two-phase 100KHz crystal oscillator. The difference frequencies are then passed through a pair of four-pole maximally flat active low pass filters with selectable cutoff frequencies. The low frequency filtered signals from the two channels are then chopped at 100KHz, again 90° out of phase, and recombined in a summing circuit. The summed signal is amplified and rectified, and drives the meter and meter analog.

Phase information can be obtained from the DC outputs of and R and J channels. The R channel balanced modulator is driven from the same phase of the two-phase 100KHz crystal oscillator as the BFO output modulator. Thus, a signal from the BFO output - of low enough frequency not to have phase shift introduced by the two low pass filters in the circuit - will produce a DC output from the R channel, and none from the J channel, which has been chopped at 90° out of phase. If phase shift is introduced between the BFO output and the input to the first modulator the R output will decrease and the J output increase until, at 90° there will be no R output and maximum J output. In this way the Model 306TDL can separate the real from the imaginary parts of a voltage, derived from a device driven by the BFO output.

The BFO output is a constant amplitude signal of exactly the frequency to which the instrument is tuned. It is obtained by mixing the 10KHz fixed oscillator with the 100 to 150KHz variable oscillator and taking the difference frequency. Unwanted higher frequency moculation products are removed by a low pass filter.

The RESTORED signal output is a filtered replica of the input signal exactly equal in frequency and proportional in amplitude. It is obtained by mixing the summed 100KHz signal with the variable oscillator output and taking the difference frequency.

In the AFC and TRACKING modes a phase detector compares the phase difference between the second (RØ,JØ) and fourth (Rn,Jn) poles of both of the low pass filters and produces a DC voltage of proper amplitude and polarity to tune the variable oscillator, so that the desired signal is in the center of the pass band. Control of the variable oscillator by the output of the phase detector is inhibited unless the signal is in excess of the tracking threshold. The output from the phase detector is attenuated in accordance with the bandwidth, tracking range, and tracking time in use.

B. CIRCUIT DESCRIPTION

1. SWEEP GENERATOR & IMPEDANCE CONVERTER - SCHEMATIC 8542

The Sweep Generator itself consists of Q1 and IC1, which form a Miller Integrator that charges C1 linearly with time. When the voltage across C1 reaches a value equal to a reference voltage set by R6, IC2 prohibits further charging of C1. In the RESET mode C1 will remain discharged by Q2.

IC3 is an impedance converter which provides a variable reference voltage to Ic4. IC4 also receives a differential reference voltage from the frequency control potentiometer on the front panel. IC4's output is used to drive the frequency analog and to control the frequency of the variable oscillator.

2. VARIABLE OSCILLATOR and DIVIDE BY 4 CIRCUIT - SCHEMATIC 8543

The variable oscillator is basically an extremely stable, free-running multi-vibrator, Q1 and Q7. Its frequency is controlled from the impedance converter by linearly varying the current through Q2 and Q8. This current varies the discharge time of the timing capacitors C1 and C2. Q3 and Q6 function as non-linear collector loads to keep the dissipation in the circuitry at a minimum. Since multi-vibrators are often hard to start, there is a self-starting circuit consisting of Q4 and Q5. The output of the multi-vibrator is isolated and amplified by Q10 to provide maximum stability. The output of the oscillator is divided by 4 to provide the 100 to 150KHz variable oscillator output.

3. PREAMPLIFIER AND FIRST MODULATOR - SCHEMATIC 8544

The input is a 1 megohm step attenuator using reed switches for control. Q1 is a low noise source follower which drives the variable gain amplifier IC1. A low pass filter rejects out of band frequency components which would result in spurious signals in the first modulator. The signal is buffered by IC2 and modulated by the FET chopper Q5. As the instrument is tuned, the chopping frequency varies from 100KHz to 150KHz. A 100KHz I.F. filter suppresses transients and harmonics of the modulator.

4. BANDPASS FILTER, STEP ATTENUATOR and IF LOG AMPLIFIER - SCHEMATIC 8545

The output of the 100KHz bandpass filter feeds amplifier IC1, which in turn feeds the MILLIVOLTS FULL SCALE step attenuator. The IF output amplifiers, IC4 and IC5 are driven directly from the step attenuator.

In the log mode of operation IC2 and IC3 are variable gain amplifiers. The compression elements CR1 and CR2 control the gain which is inversely proportional to the current drive from the meter circuit. The traps in the feedback loop supress unwanted signals generated by the non-linear compression elements.

5. ±10 VOLT SUPPLIES, +5 VOLT SUPPLY - SCHEMATIC 8546

The -10 Volt Supply has as its reference CR7. The error signal between this reference and the midpoint of the voltage divider formed by R7 and R10 is amplified by IC1, which drives the pass transistor Q3. The +10 Volt Supply is identical except for polarity. The +5 Volt Supply is similar except its reference is obtained from a divider, R5 and R6, from the +10 Volt Supply.

6. METER CIRCUIT - SCHEMATIC 8547

IC1 is a simple buffer to drive the meter and the Meter Analog output. A signal level or threshold detector (IC4) is used to gate the threshold control on in the presence of a signal.

7. SUMMING AMPLIFIER AND DETECTOR - SCHEMATIC 8548

The quadrature chopped signals from the Low Pass Filter Amplifier and Chopper are summed and filtered by the amplifier consisting of IC1 and its associated

filter networks. This results in a 100KHz carrier proportional to the input signal with a bandwidth as selected by the Bandwidth Control and has 24dB/Oct. skirts. IC4 performs the same function except the signal to be summed is derived from the output of the second pole of the four-pole low pass filters. The first summing network is called the (Normal) channel and the second the Ø (Phase) channel. If the signal is detuned there will be a phase difference between these carrier signals.

A phase detector consisting of squaring amplifiers IC3 and IC5 and a comparator IC6 control the VCO in the Tracking and AFC mode to follow a drifting signal. Q6 is a gate to inhibit action for a no signal condition.

The normal channel signal is amplified by IC2 to drive the RESTORED circuit and the synchronous detector Q1.

8. L.P. FILTER CAPACITOR - SCHEMATICS 8549 & 8550

The capacitors determining the active Low Pass Filter bandwidths are switched into the filter by a series of FET switches as selected by the Bandwidth Switch.

9. LOW PASS FILTERS AND AMPLIFIERS - SCHEMATIC 8551

The R and J Channel filters and amplifiers are identical. Each of the filters consist of two two-pole RC active networks with capacitors selectable by the BANDWIDTH Switch. The first section has a gain of approximately 50. The second section has a gain of slightly more than 1. The gains of the two amplifier sections are adjusted so that the overall response is that of a maximally flat or Butterworth filter. Separate outputs are taken from both the second (Ø) and the fourth (N) poles of each filter. The phase difference between these points is later measured in the phase detector and used to control the variable oscillator in the AFC mode. The gain in these channels is pre-set at the factory and should not be changed. Q1, Q2, and Q3 and Q4 are the choppers for the Ø and N channels.

10. FIXED OSCILLATOR AND SECOND MODULATOR - SCHEMATIC 8552

The 100KHz fixed oscillator frequency is derived from a 400KHz crystal oscillator. The 400KHz output is divided by four by IC2. The circuitry is so arranged as to obtain two 100KHz outputs precisely 90° out of phase. The 100KHz quadrature signals are used to drive the second modulators, Q3 and Q6 through Q4 and Q7. The outputs of the modulators are fed to the

two low pass filters. The choppers are also driven from Q4 and Q7.

The Meter Zero controls provide a means of periodically balancing critically matched circuits which are subject to change with time and temperature. Circuit unbalance is indicated by a finite meter reading with no signal applied and should be "zereod out" (minimum scale reading) for correct operation.

11. TIME BASE - SCHEMATIC 8553

The 100KHz Fixed Oscillator is used to generate an accurate 250 millisecond time base for the frequency readout. IC1, IC2, IC4 and IC5 provide the countdown circuit. IC6 and IC7 generate the latch transfer and counter reset pulses. IC6D inhibits the counter input during the latch transfer.

IC3 decoder strobes the LED readout anodes and the tri-state latches (Counter and Multiplexer board).

If the total count during the 250 m.s. period is less than 100KHz (indicating the VCO is tuned below the fixed oscillator, i.e., negative tuning) IC8 will blank the 1st and 2nd MSD.

12. COUNTER AND MULTIPLEXER - SCHEMATIC 8554

The 400KHz to 600KHz VCO signal is clocked into 5 decade BCD counter. Four times per second the count is transferred to the latches. These latches are strobed by the TIME-BASE generator and drive the BCD to 7 segment decoder on the Readout board. The over-under count drives the blanking circuit on the TIME-BASE generator.

13. BFO AND RESTORED - SCHEMATIC 8555

The output of the VCO through Q1 switches Q2 and Q3, modulators of the fixed oscillator and the N carrier signals. The difference frequency of each modulator is fed through an active low pass filter (4 pole); the output level is adjusted by a variable attenuator placed between the two sections.

CALIBRATION

1. GENERAL

The Model 306TDL is a precision instrument, the accuracy of which depends, in large part, on critically balanced DC circuitry. The circuits in turn are designed to operate over a moderate temperature range. However, the instrument cannot cope with thermal shocks or transients which cause differential temperatures to occur between individual components. The closed-box environment provided by the Model 306TDL case affords its circuits both thermal-transient and electrostatic shielding, thereby resulting in more stable operation. During calibration similar protection may be required in the interest of accuracy. It is also recommended that the "extender board" supplied with each instrument be used in the case of those adjustments which cannot be made without removing the circuit board. If a circuit board must be temporarily removed from its socket, or if the unit is momentarily turned off, be sure to allow the instrument time to restabilize before making further adjustments.

Following is an outline of the setup procedure. It is important that the adjustments be made in the prescribed order, inasmuch as some of them depend upon completion of the previous ones.

C A U T I O N

Included in this procedure are a number of adjustments which require the actual selection and installation of components. These particular adjustments are intended to be made ONLY on new assemblies or those which have received catastrophic damage, necessitating a major overhaul. An asterisk indicates factory selected components on the schematics.

Those adjustable controls not covered in the "Calibration Procedure" should NOT be adjusted. These are set at the factory during initial calibration and will not require further adjustment.

2. Adjustment Procedure Outline

a. Frequency Determinants

(1) Power Supplies

(2) Variable Oscillator and Impedance Converter

(3) Fixed Oscillator

(4) Sweep Circuits

b. Signal Channel

(1) Meter Zero Adjustments

(2) R/J Channel Balance

(3) Calibrate Gain Circuit

(4) Check Systems Gain

3. Test Equipment Required

a.	VOM	- Avometer or equivalent 20,000 ohm/Volt
b.	D.C. Voltmeter	- 0.1% Accuracy
c.	Oscillator	- 10Hz to 100KHz, 1 Volt output
d.	VTVM	- HP 400D or equivalent
e.	Oscilloscope	- Tektronix 503 or equivalent
f.	Oscilloscope	- 50MHz response with low-capacitance probe
g.	Frequency Counter	- Range 500KHz, accuracy 0.1%
h.	Decade Amplifier	- GR 1450 or equivalent

4. Initial Setting of Controls

METER ZERO CONTROLS	Midrange
METER T.C.	.1 SEC.
MILLIVOLTS FULL SCALE	1000
BANDWIDTH	100Hz
FINE Control	Midrange

METER MULTIPLIER	X1
Variable Control	Calibrated
SWEEP RANGE	50 KHz
SWEEP TIME	50 SEC.
Sweep Function	RESET

5. Calibration of Frequency Control Circuits

NOTE: ALLOW INSTRUMENT TO WARM UP FOR 15 MINUTES BEFORE ATTEMPTING THE FOLLOWING PROCEDURES:

a. POWER SUPPLIES Assy 05; Test Equipment; Item b

(1) Monitor the minus 10 volt T.P. with D.C. Voltmeter. Should read minus 10 volts ±100 millivolts. If necessary, adjust R1 for correct reading.

(2) Monitor the plus 10 volt T.P. Adjust R3 if necessary.

(3) Monitor the plus 5 volts T.P. 4.75 to 5.25 volts is within range.

b. SWEEP GENERATOR Assy 01; Test Equipment; Item b

Front panel controls as "Initial Setting"

(1) Monitor sweep T.P. with Voltmeter. Adjust R2 for 0 volts ±10 millivolts. Set SWEEP to SINGLE. At the end of the sweep period, 50 sec., adjust R6 to 5 volts ±10 millivolts. The above T.P. is also the SWEEP ANALOG.

c. VARIABLE OSCILLATOR Assy 02; Test Equip; Item b

Front panel controls as "Initial Setting"

(1) Adjust Variable Oscillator Reference Adj. (+5.25V) R22, using T.P. to +5.25 volts +10 mv.

d. IMPEDANCE CONVERTER Assy 01; Test Equip; Item b

(1) Turn Sweep to Reset. Monitor Frequency Analog T.P. with voltmeter. Set FINE Frequency tuning control to midrange and the COARSE tuning control for 0 volts ±10mv at Frequency Analog T.P. Switch SWEEP to SINGLE, allow instrument to complete sweep,

d. IMPEDANCE CONVERTER Assy 01; Test Equip; Item b (CONT)

(1) adjust Frequency Analog +5 Volt Adj. (R22) to 5 volts ±10 mv.

(2) Set Sweep Range to 5 KHz. Frequency Analog T.P. should be 0.5 volts ±25 mv.

(3) Check Sweep Times. Set SWEEP to RESET, and, using a watch or clock, measure the time for the SWEEP ANALOG or SWEEP T.P. to sweep from 0 to 5 volts when the SWEEP is set to SINGLE. Since this function is used in X-Y plotting of data, the time is not critical, ±20% is adequate. For the longer sweep times a timing of a partial sweep will decrease the test time.

e. VARIABLE OSCILLATOR Assy 02; Test Equip; Item b

Front panel controls as in "Initial Setting"

(1) Adjust Variable Oscillator Zero Adj., R1, for 00.000KHz.

(2) Tune the COARSE and FINE tuning controls for 5 volts at the Frequency Analog T.P. on Assy 01, then adjust the 50KHz Adj. R6 for 50KHz display on the front panel readout.

f. FIXED OSCILLATOR Assy 12; Test Equipment; Item g

(1) No Frequency adjustment is required on the Fixed Oscillator. If there is a question of its frequency, use a scope probe into the counter from the crystal (top terminal). The frequency should be 400KHz ±0.01% at room temperature.

6. Calibration of the Signal Channel

Front panel controls as in "Initial Setting" except, tune the frequency readout to 10KHz and set MILLIVOLTS FULL SCALE switch to 3.

a. LOW PASS FILTER Assy 11; Test Equip; Item C

(1) Adjust the front panel METER ZERO controls to midrange.

(2) Adjust the COARSE R (R19) and J (R1) ZERO for minimum meter deflection.

(3) Adjust front panel METER ZERO controls for accurate minimum deflection.

(4) Monitor junction of C31, R43, CR4 and CR5 (BD 07) with oscilloscope. Adjust RØ (R38) and JØ (R35) of BD 11 for minimum signal.

(5) Set MILLIVOLTS FULL SCALE Switch to 1000 and apply 1 volt 10KHz sinewave to the input. Carefully tune either the generator or Model 306TDL to within a few Hz of each other. Then adjust the R-J Bal. control (R17) for maximum meter stability (±2% is acceptable).

b. METER CIRCUIT Assy 06; Test Equip; Items b and c

(1) With no signal at the input, tune to approximately 10KHz (be sure the Meter Zero controls are carefully adjusted). Adjust T.C. Bal (R1) for zero on the meter.

(2) Apply a 10KHz signal and monitor the Meter Analog T.P. Adjust signal level for 1 Volt D.C. output, then adjust Meter Cal. Adj. (R26) for a reading of 1.0 on the meter.

c. SUMMING AMPLIFIER AND DETECTOR Assy 07; Test Equip; Items c, d and e.

(1) With 1 volt 10KHz applied to the input, adjust SYSTEM GAIN with R5 for 1 volt meter reading.

(2) Using the X and Y inputs of a scope monitor the R and J T.P.'s on Bd 11, Low Pass Filter (scope sensitivity 50mv/cm with D.C. coupling). A rotating circular pattern will be observed. Set to AFC and SINGLE. Adjust Track Bal. Adj. for minimum rotation.
NOTE: Often a phase lock on the signal is obtained, but is not required for AFC operation. Check the Track and Search Track as above.

(3) Vary the input Frequency and the instrument should follow the signal over approximately ±4 bandwidths in the A.F.C. mode and the required ranges in Track or Search and Track.

(4) Decrease the signal level to approximately 10% of FULL scale; Adjust the Threshold Adj. (R29) on Assy 06 until the lock is released.

d. LOG CIRCUIT Assy 06

(1) Tune to 10KHz and apply a 1 volt 10KHz signal.

(2) Switch the MVFS switch to LOG and Meter Multiplier to X1.

(3) Adjust LOG Offset, R17, for 0 dB.

(4) Attenuate the input 40dB and adjust Log Span, R22, for a meter reading of -40dB. If -40dB reading is incorrect adjust R22 to increase error, then readjust R17.

NOTE: The above adjustments are interdependent, therefore, if the instrument has been grossly misaligned, several adjustments. may be required.

(5) Check Log Scale Tracking ($\pm$2dB from 0 to -70dB).

TABLE 4 - 1 PLUG-IN BOARD IDENTIFICATION

BOARD NO	FUNCTION
01	Sweep Generator and Impedance Converter
02	Variable Oscillator
03	Pre-Amplifier and 1st Modulator
04	I. F. Amplifier
05	Power Supply
06	Meter Circuit
07	Summing Amplifier and Detector
09	L.P. Filter Capacitor
10	" " "
11	L.P. Filter Amplifier
12	Fixed Oscillator, 2nd Modulator
13	Time Base
14	Counter and Multiplexer
15	B F O and Restored
16	Extender

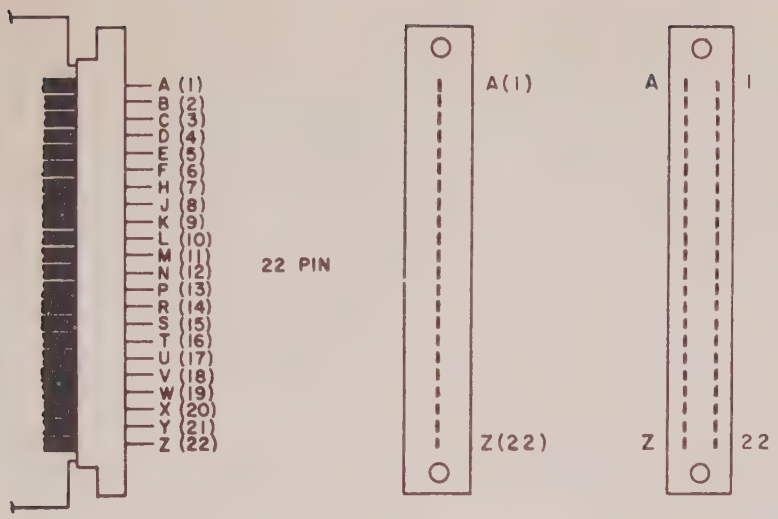


FIG. 1 PRINTED CIRCUIT BOARD LUG IDENTIFICATION

Fig. 1 illustrates the identification and orientation of a printed circuit board and connector utilizing 22 pins.

When a printed circuit board of a lesser number of pins is called for, the same designating sequence shall apply.

When a single sided copper P.C. Board is used, its pin identification shall be as shown in Fig. 1, and its schematic references shall be A(1), B(2), C(3) etc. The copper side faces the observer when viewed as shown at the left.

When using a double sided copper P.C. Board, its pin orientation shall be as shown in Fig. 1 and its schematic references shall be as follows:

a. (A), (B), (C) etc. signifies that electrical connections are made to lettered side of P.C. Board (A side).

b. (1), (2), (3) etc. signifies that electrical connections are made to numbered side of P.C. Board (1 side).

c. A(1), B(2), C(3) etc. signifies that electrical connections are made to both sides of P.C. Board simultaneously, i.e., A and 1 are schematically connected.

SEMICONDUCTOR LEGEND

Changes and improvements in the semiconductor products available for commercial use necessitate type changes from time to time. To eliminate confusion and costly paperwork, many of these changes will be covered in the following legend. The purpose of this legend is to acknowledge the fact that the type number on a semiconductor found in a piece of equipment will not necessarily correspond with the type number given on the schematic diagram.

The legend is not intended to be an interchangeability list although in many cases good quality components* within a given category may be substituted with acceptable results. Normally, replacements should be made using components having the same type number as the component being replaced.

Those components bearing an asterisk on the schematic diagram are factory selected components and should be obtained from Scientific-Atlanta, Inc., New Jersey Division.

*It should be noted that the incoming inspection procedure followed at Scientific-Atlanta includes noise screening on most semiconductors.

TYPE NO. ON SCHEMATIC	TYPE NO. IN EQUIPMENT
1N482A	1N914, 1N4151
1N703	1N749A
1N709	1N753, 1N825A
1N753	1N825A
1N2859	1N3254, 1N4001
1N2862	1N3254, 1N4001, 1N4004
1N3253	1N3254, 1N4001, 1N4004
1N3254	1N4001, 1N4004
1N3256	1N4006
1N3604	1N914, 1N4151
1N3605	1N482A, 1N914, 1N4151
1N4151	1N914
MPD400	1N5179
E112	2N4392, 2N5949, 2N5950, 2N5951
TIS73	E112, 2N4392, 2N5952, 2N5953
TIS74	E112, 2N4392, 2N5950, 2N5951, 2N5952
TIS75	E112, 2N4392, 2N5949, 2N5950, 2N5951
TI480	2N929, 2N930, 2N3643
TI494	2N929, 2N930, 2N3643
UC240	2N5949, 2N5950, 2N5951, 2N5952, 2N5953

TYPE NO. ON SCHEMATIC	TYPE NO. IN EQUIPMENT
2N270	2N3250, 2N3251, 2N3644
2N396A	2N1305, 2N3250, 2N3251, 2N3644
2N414	2N1305, 2N3250, 2N3251
2N929	2N930, 2N2219, 2N3644
2N1304	2N929, 2N930, 2N3643
2N1306	2N929, 2N930, 2N1304, 2N3643
2N1515	2N3250, 2N3251, 2N3644
2N1613	2N929, 2N930, 2N2219, 2N3643
2N2219	2N929, 2N930, 2N3643
2N2603	2N3250, 2N3251, 2N3644
2N3250	2N3251, 2N3644
2N3251	2N3250, 2N3644
2N3566	2N929, 2N930, 2N2219, 2N3643
2N3643	2N929, 2N930, 2N2219
2N3644	2N3250, 2N3251
2N3762	2N3250, 2N3251, 2N3644
2N3819	E112, 2N5949, 2N5950, 2N5951, 2N5952, 2N5953
2N4869	2N5949, 2N5950, 2N5951, 2N5952, 2N5953

SCHEMATIC LEGEND

k -- 1000

-- Screw Driver Adjustment

-- Front Panel Control

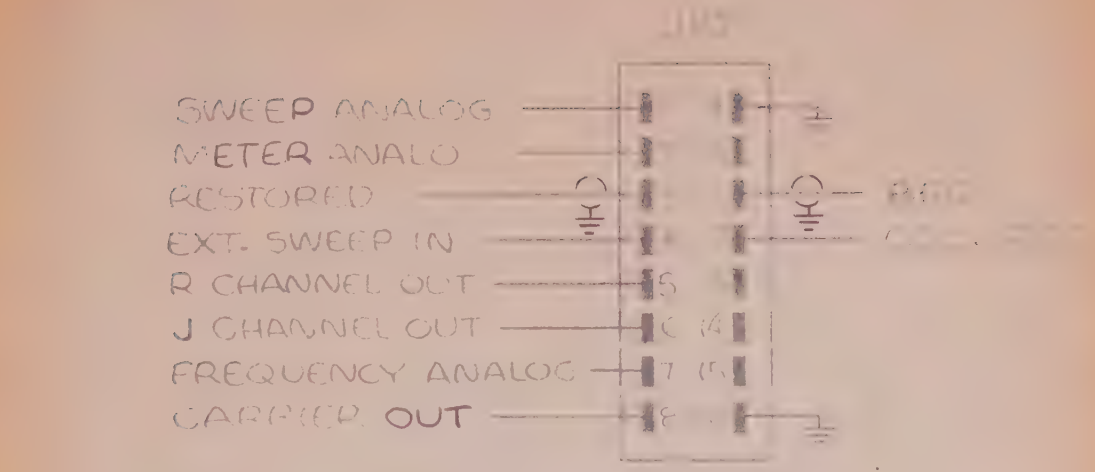
* -- Factory Select

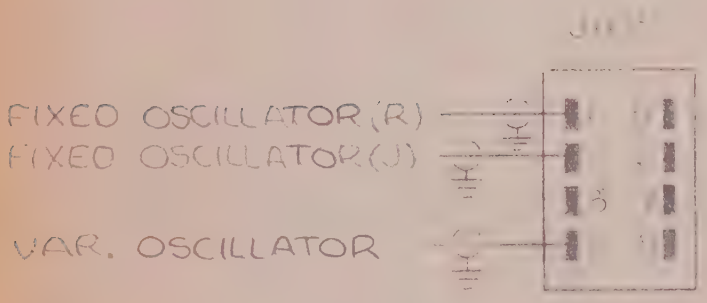
Unless Otherwise Specified:

All Resistances in Ohms

All Capacitances in Microfarads

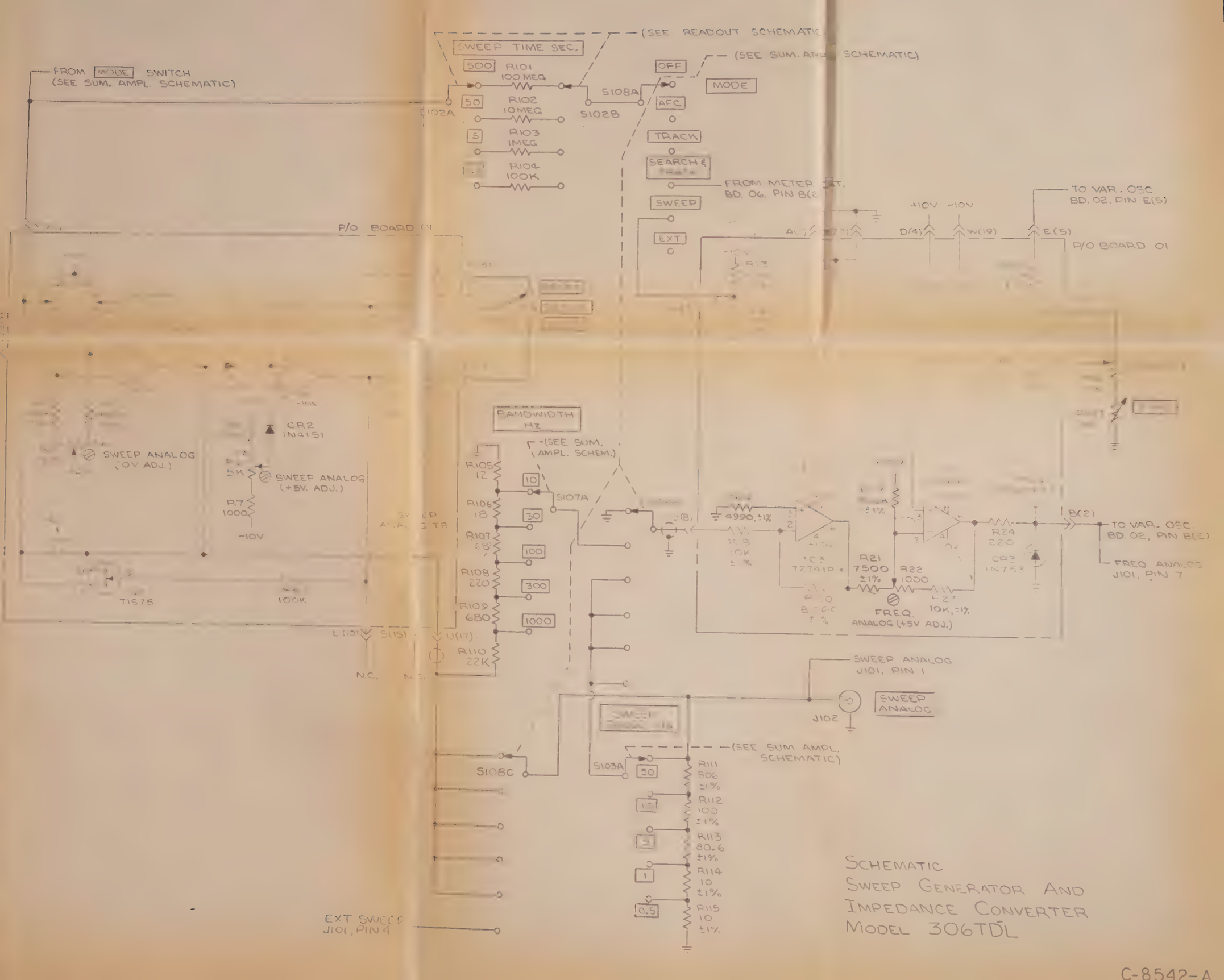
3/15/77





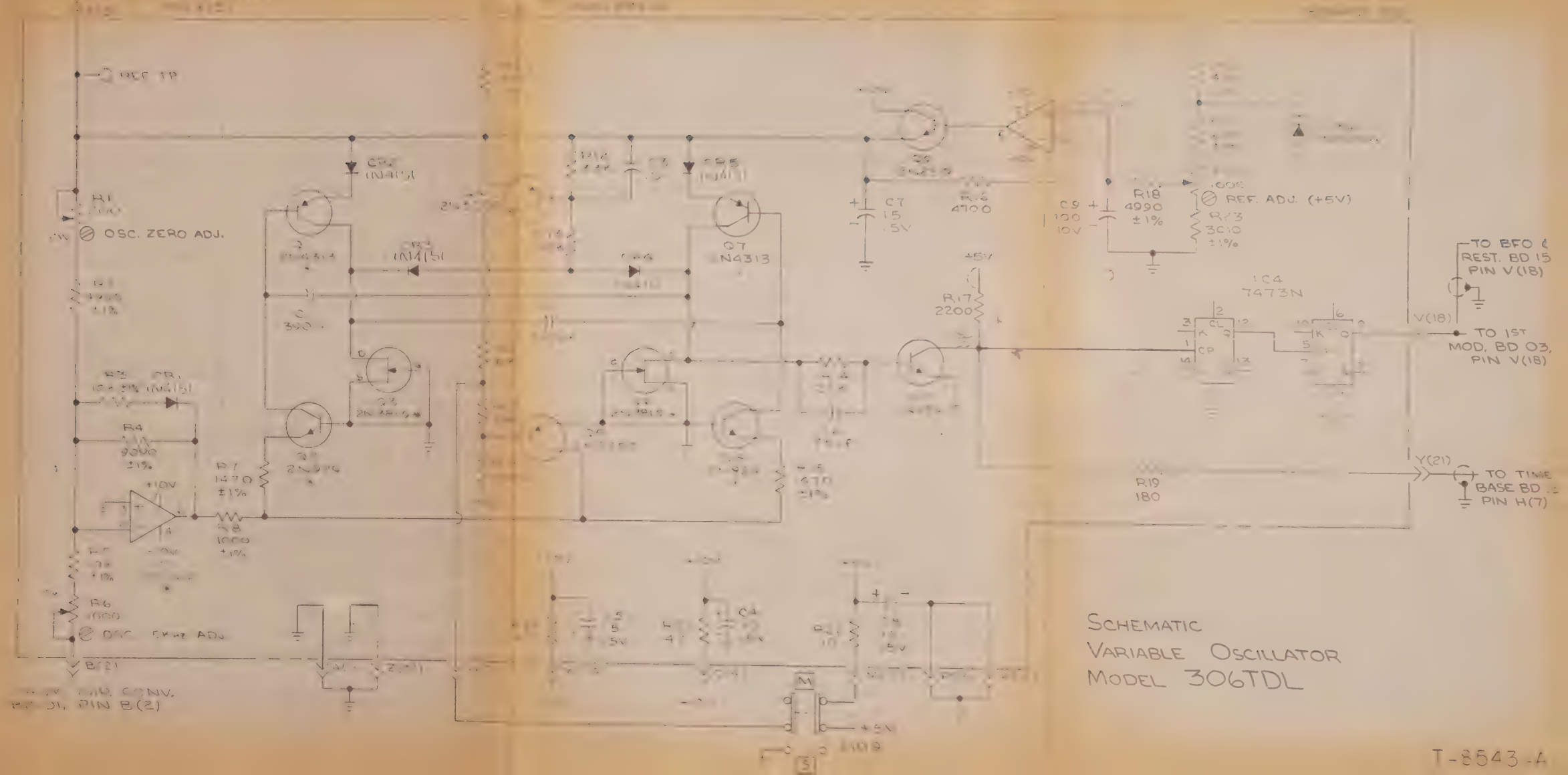
SCHEMATIC
CONNECTORS
MODEL 306TDL

A-8541-A



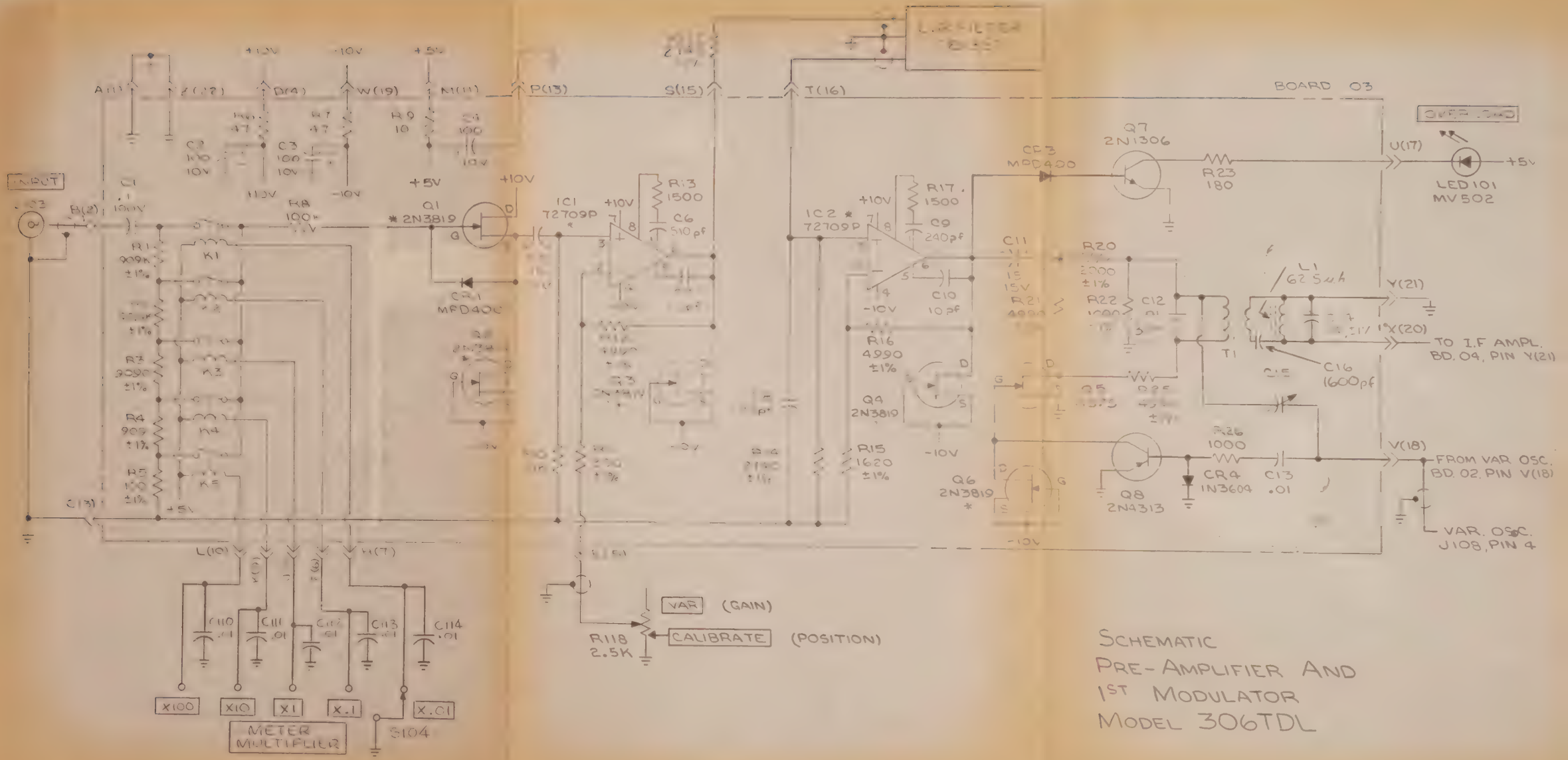
SCHEMATIC
SWEEP GENERATOR AND
IMPEDANCE CONVERTER
MODEL 306TDL

C-8542-A



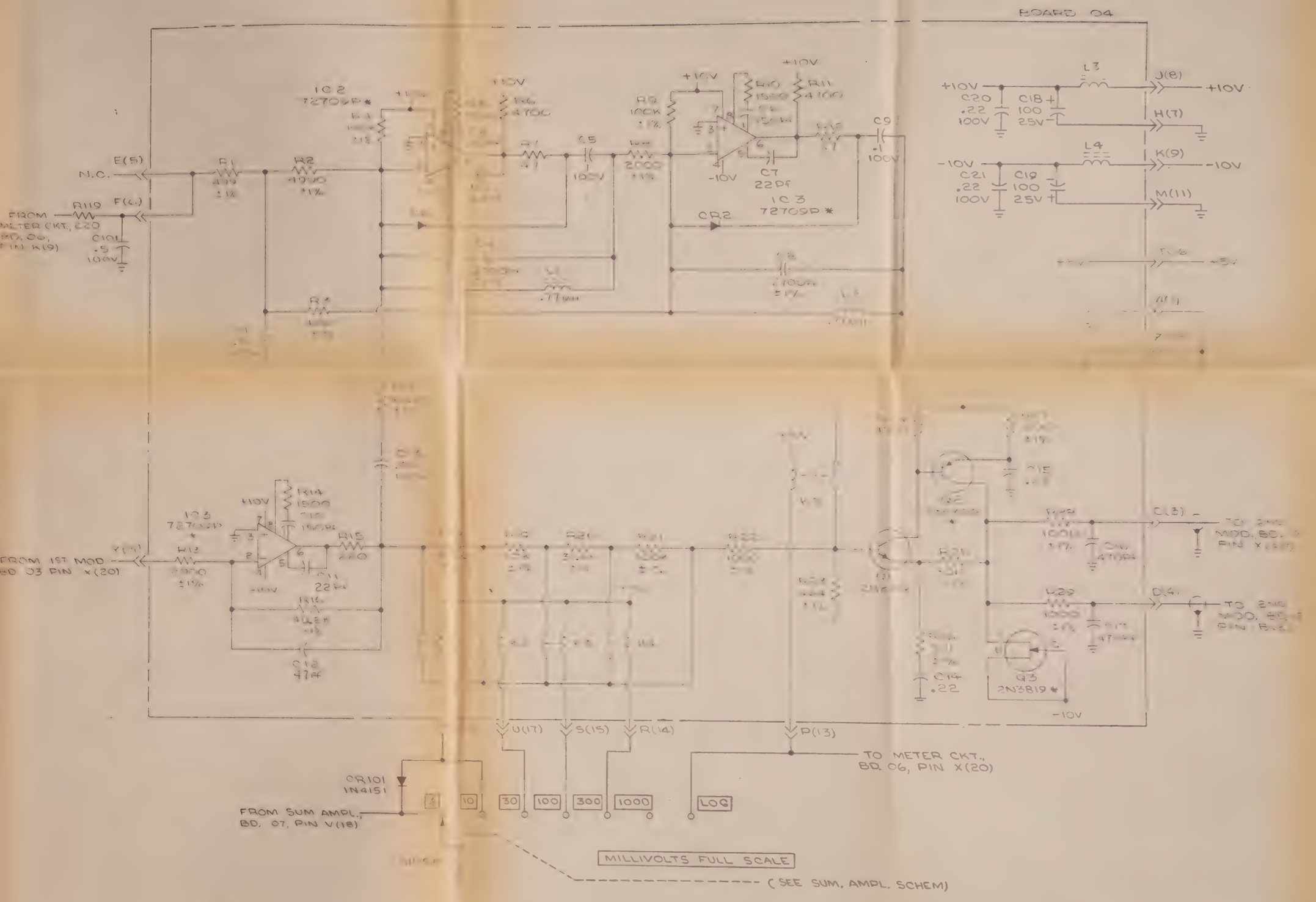
SCHEMATIC
VARIABLE OSCILLATOR
MODEL 306TDL

T-8543-A



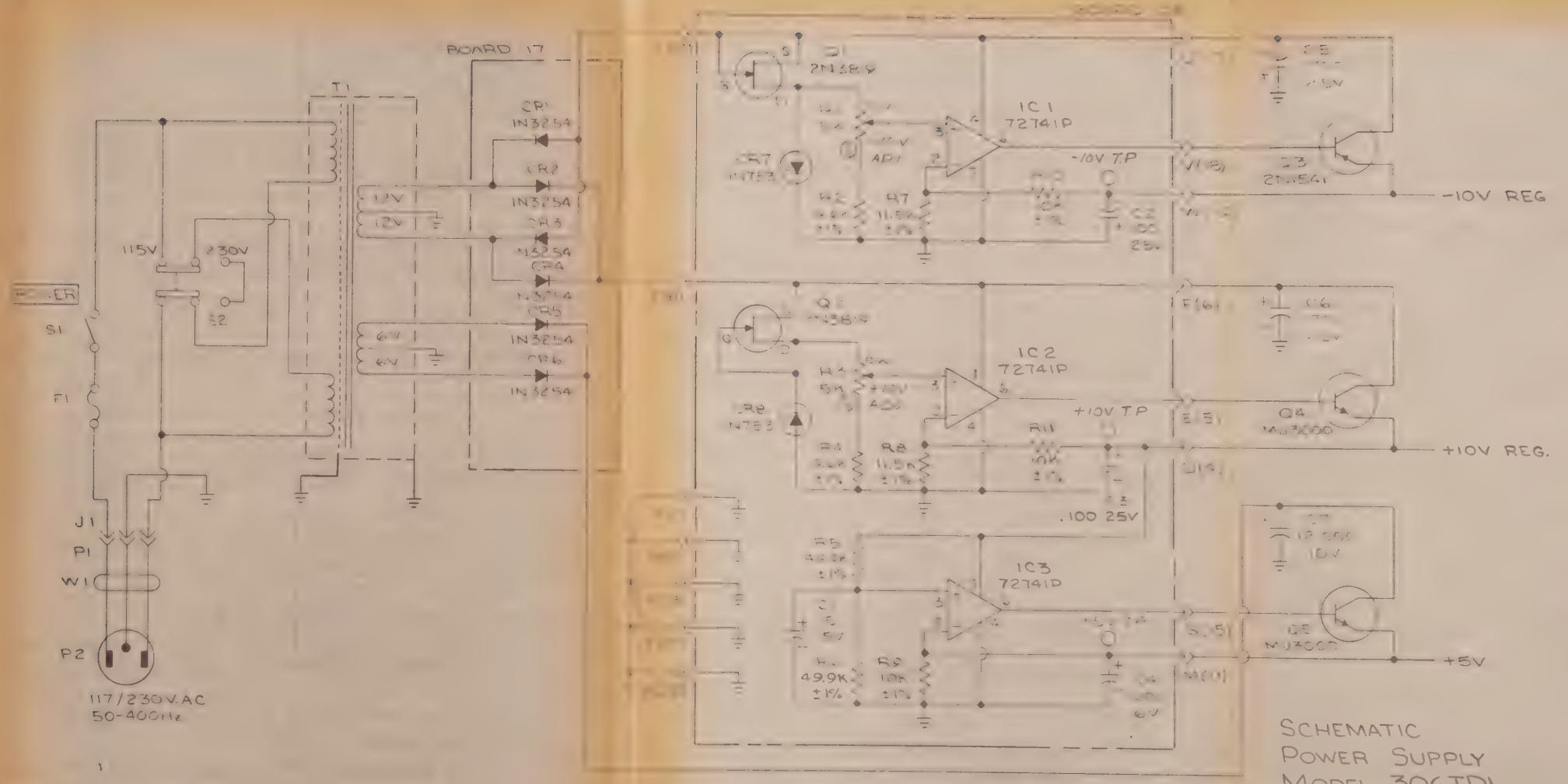
SCHEMATIC
PRE-AMPLIFIER AND
1ST MODULATOR
MODEL 306TDL

T-8544-A



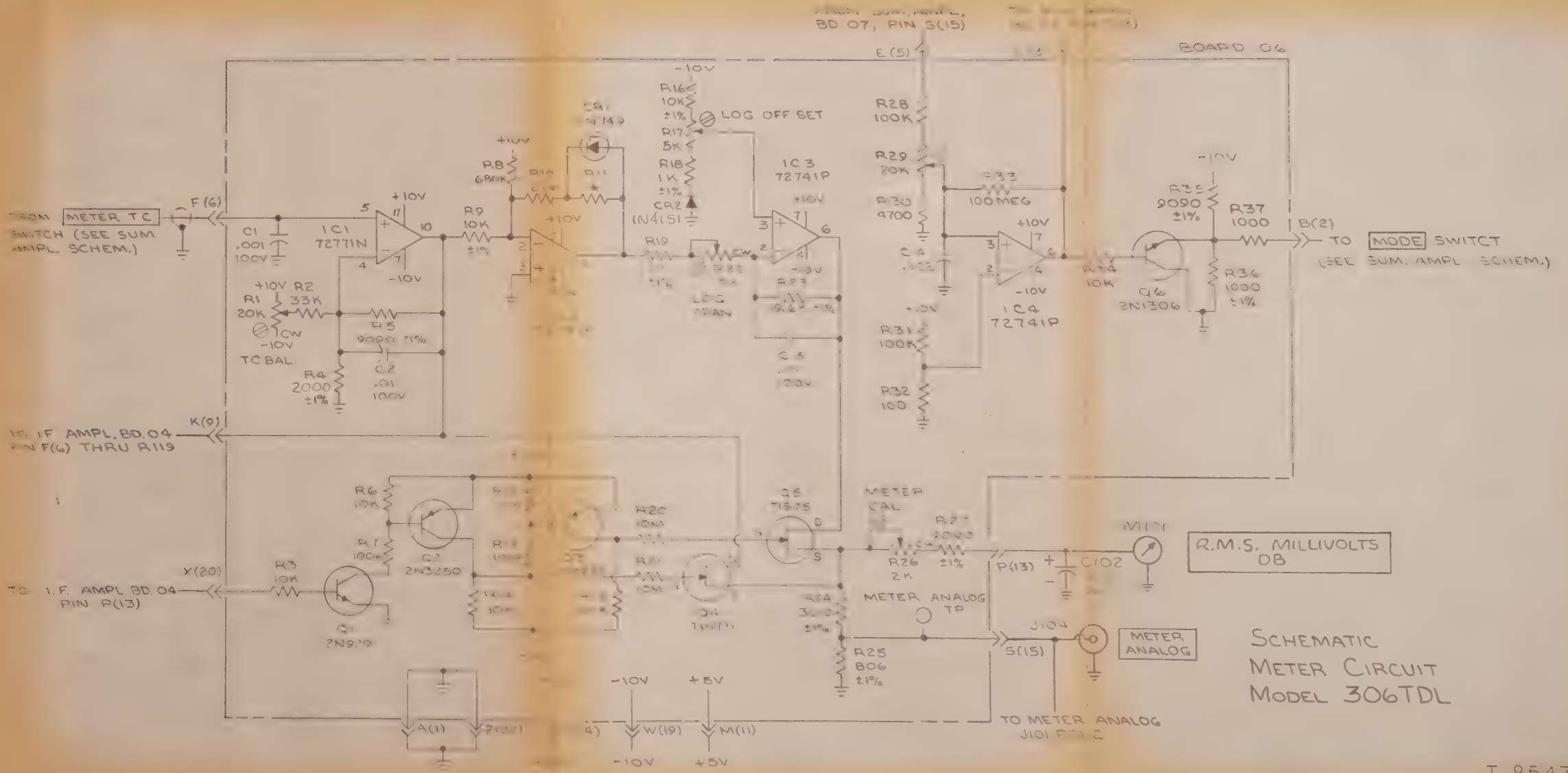
SCHEMATIC
I.F. AMPLIFIER
MODEL 306TDL

C-2048-A



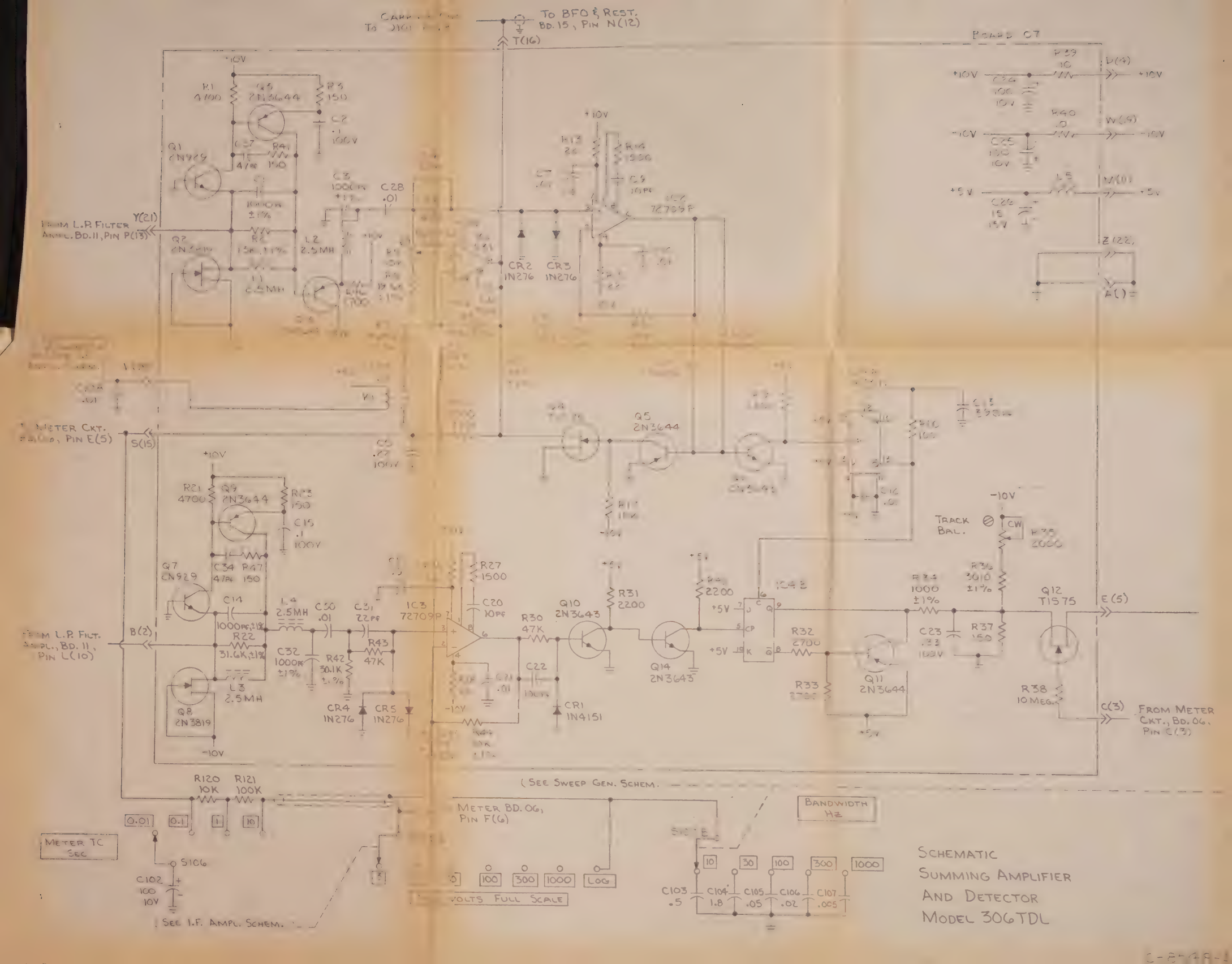
SCHEMATIC
POWER SUPPLY
MODEL 306TDL

T-8546-A

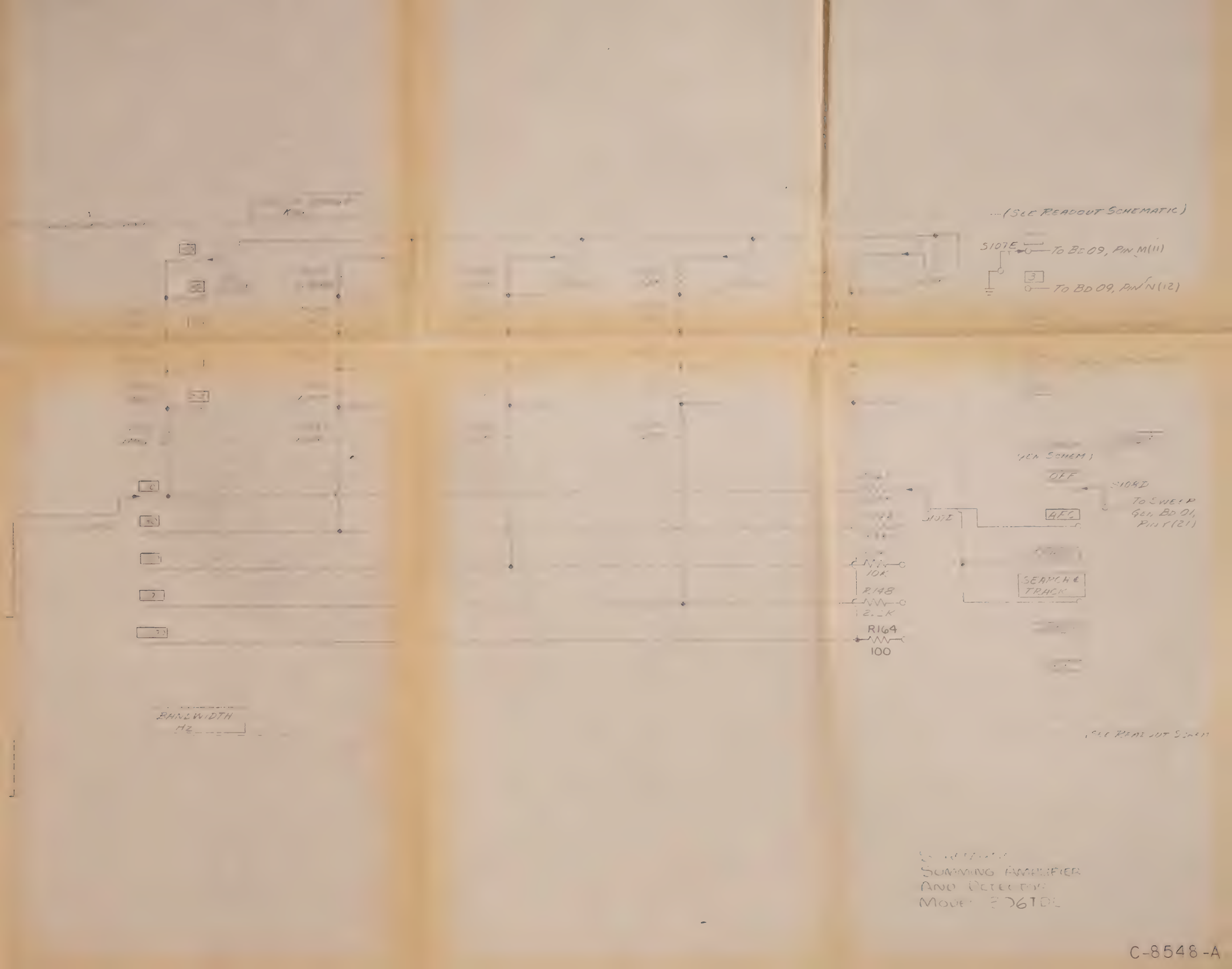


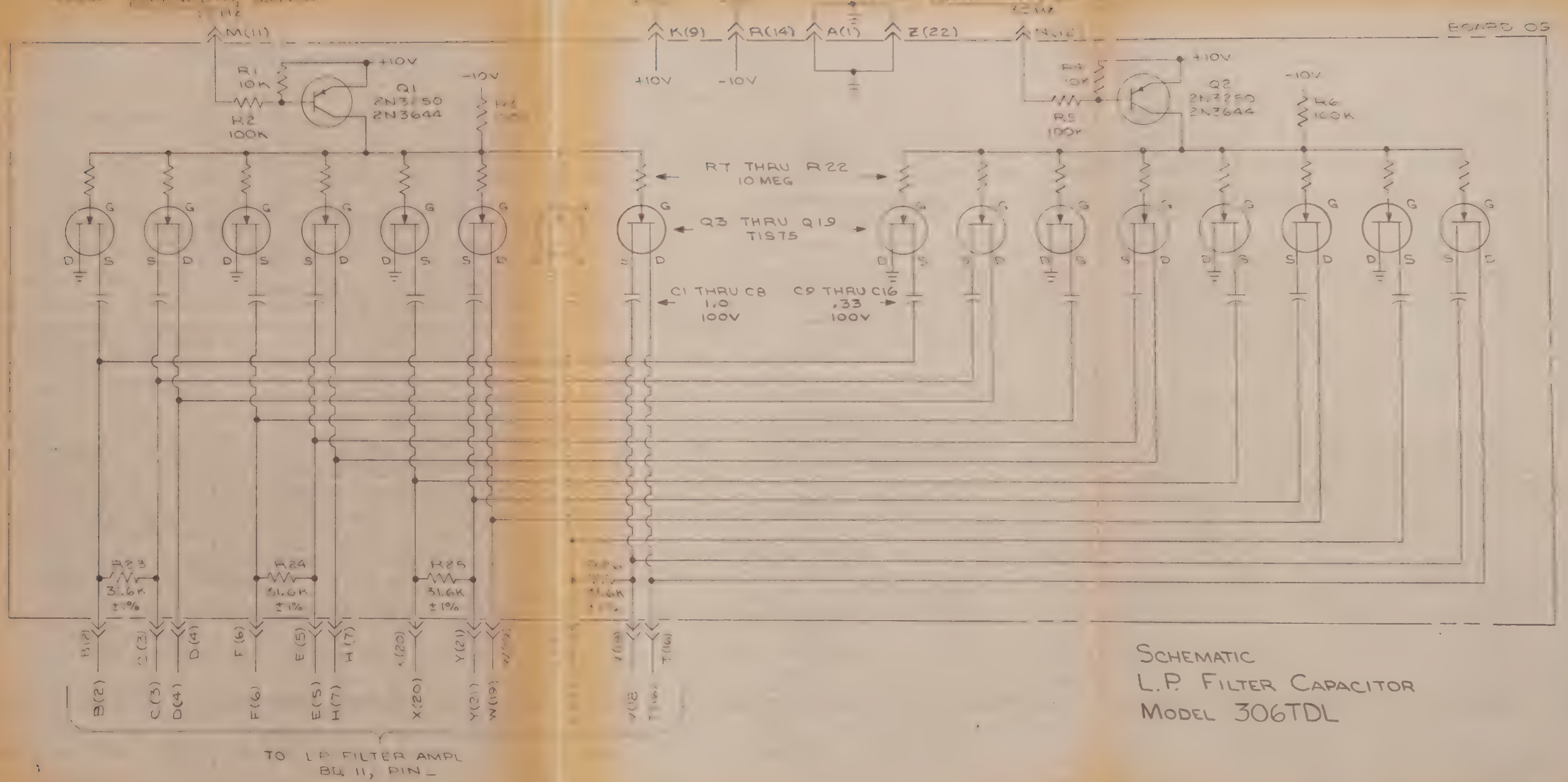
SCHEMATIC
METER CIRCUIT
MODEL 306TDL

T-8547-A



Schematic
Summing Amplifier
And Detector
Model 306TDL

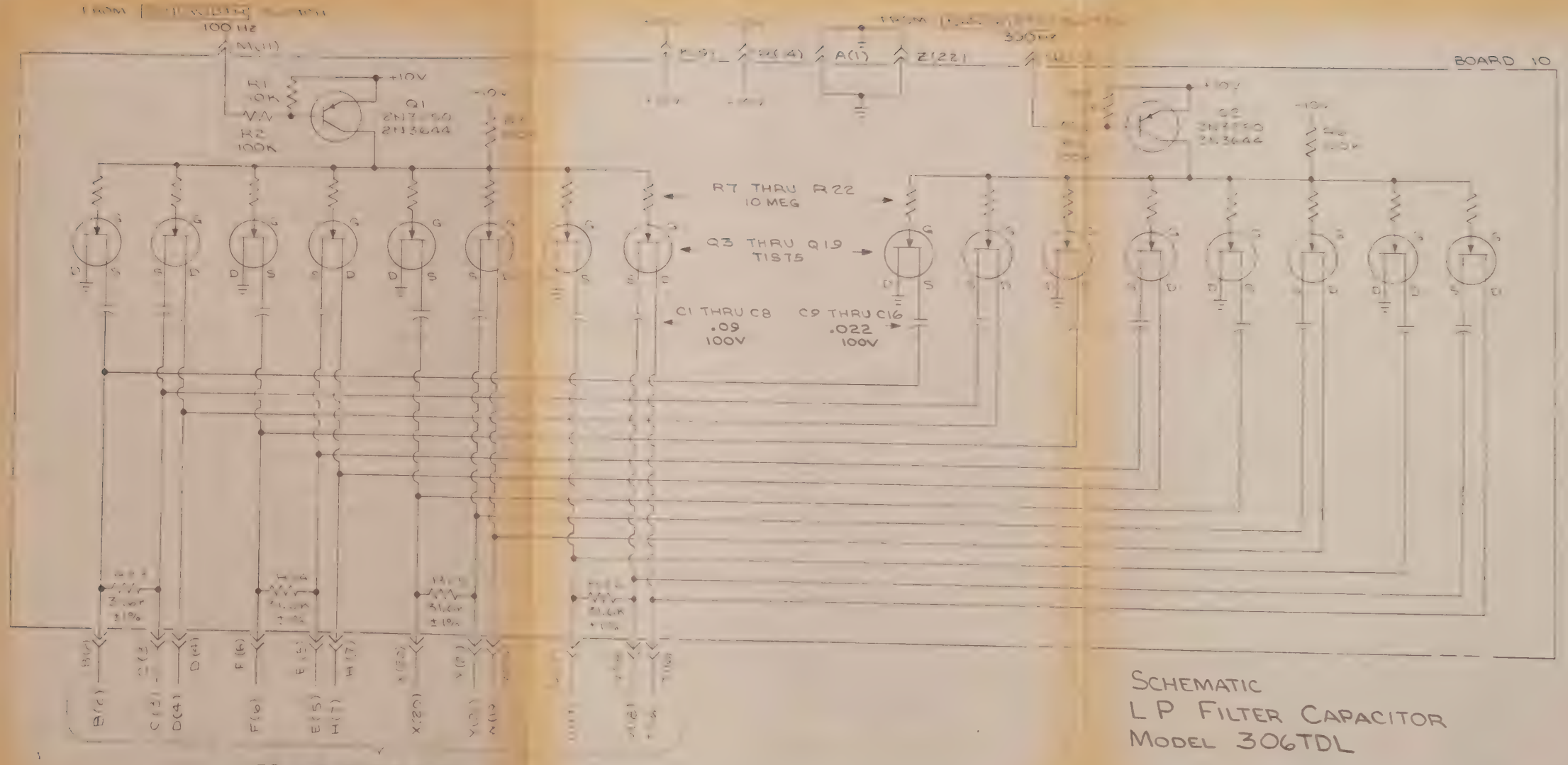

...(SEE READOUT SCHEMATIC)
S107E
TO BD 09, PIN M(11)
3
TO BD 09, PIN N(12)
(SEE SCHEM)
OFF
S108D
TO SWEEP GEN. BD 01, PIN R(21)
S107E
AFC
10K
R148
12.1K
R164
100
SEARCH & TRACK
(SEE READOUT SCHEM)
BANDWIDTH
HZ
SUMMING AMPLIFIER
AND DETECTOR
MODEL 3061DL
C-8548-A



BOARD 03

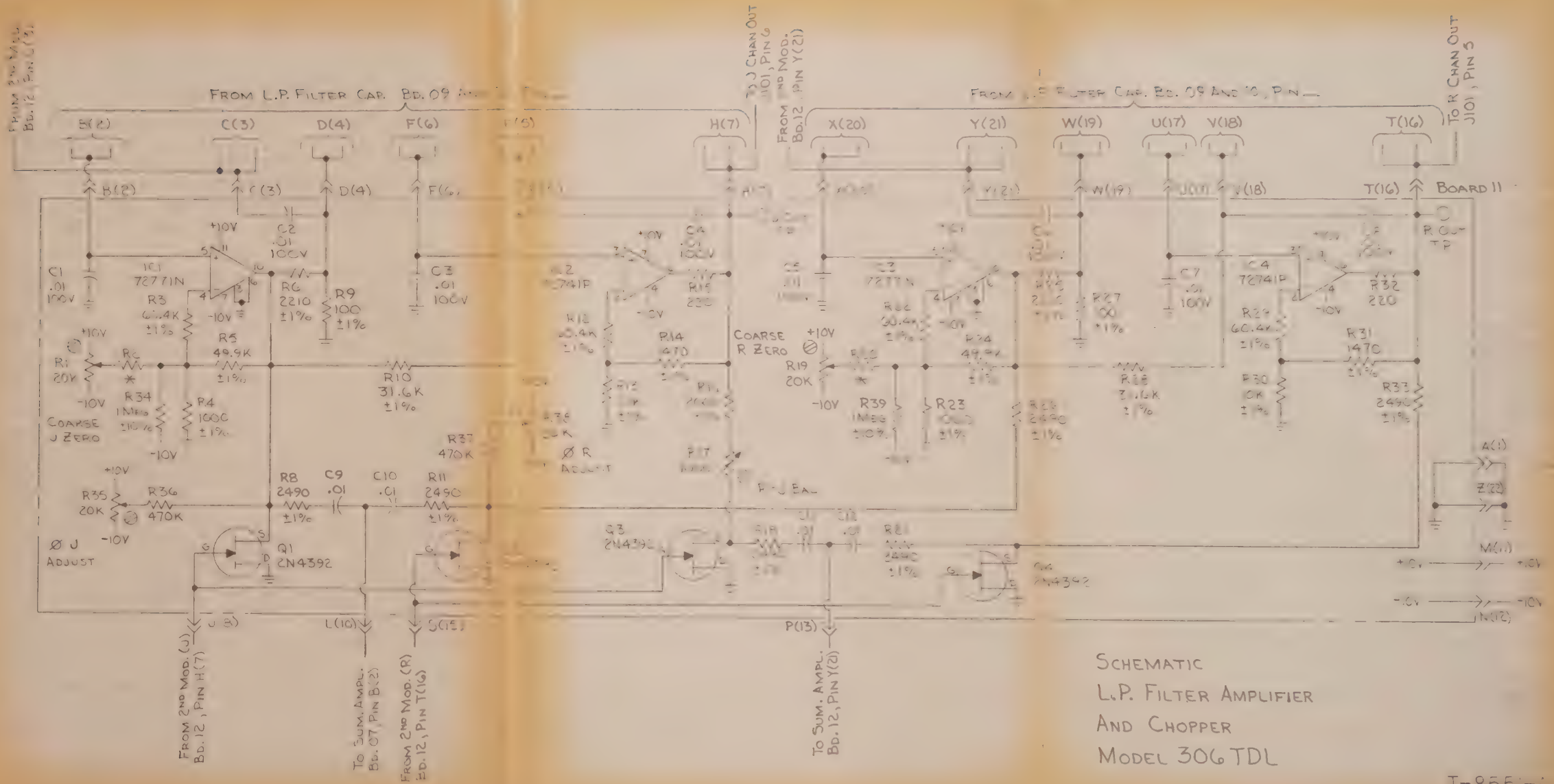
SCHEMATIC
L.P. FILTER CAPACITOR
MODEL 306TDL

T-8549-A



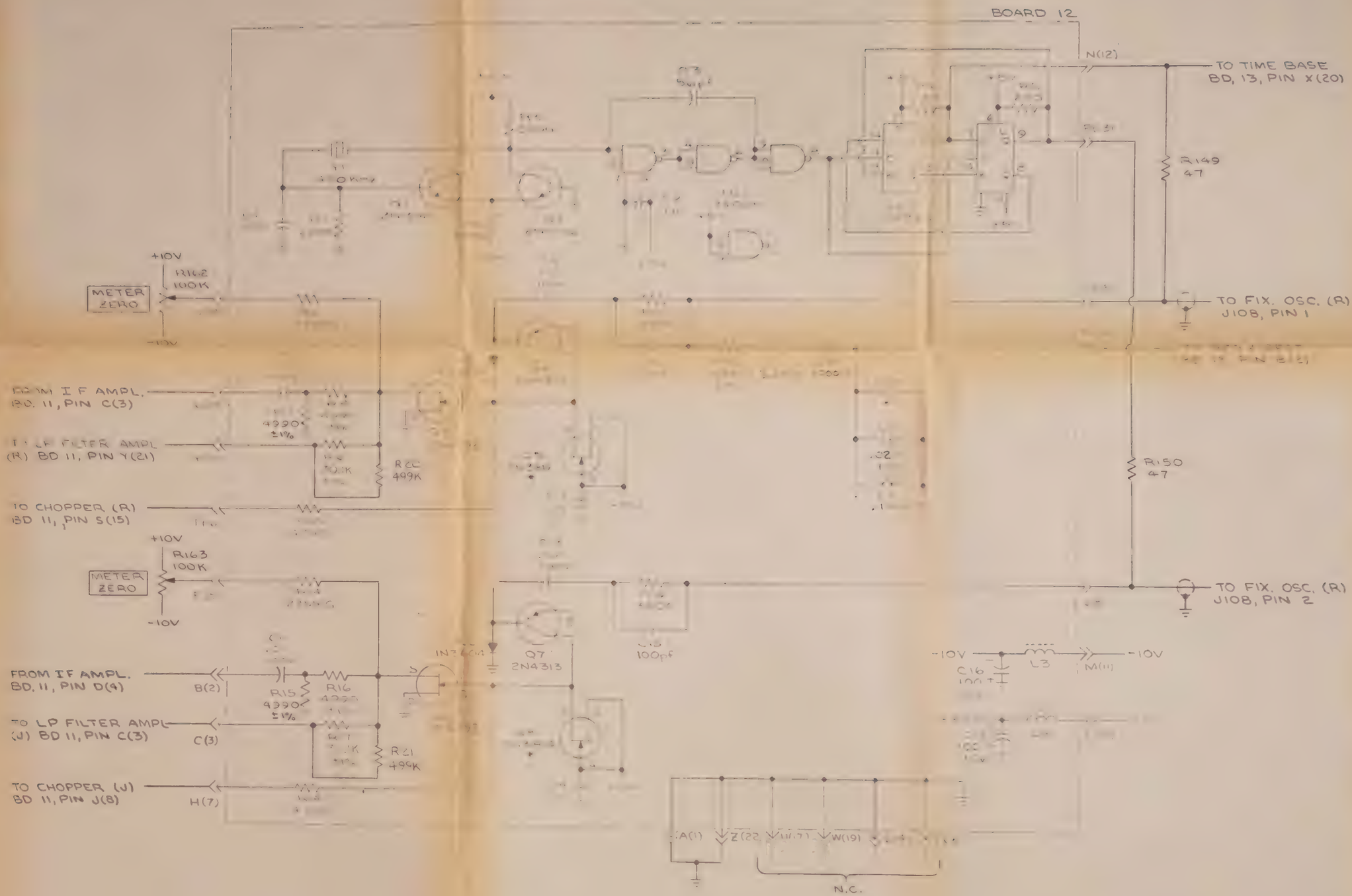
SCHEMATIC
L P FILTER CAPACITOR
MODEL 306TDL

T-8550-A



SCHEMATIC
L.P. FILTER AMPLIFIER
AND CHOPPER
MODEL 306 TDL

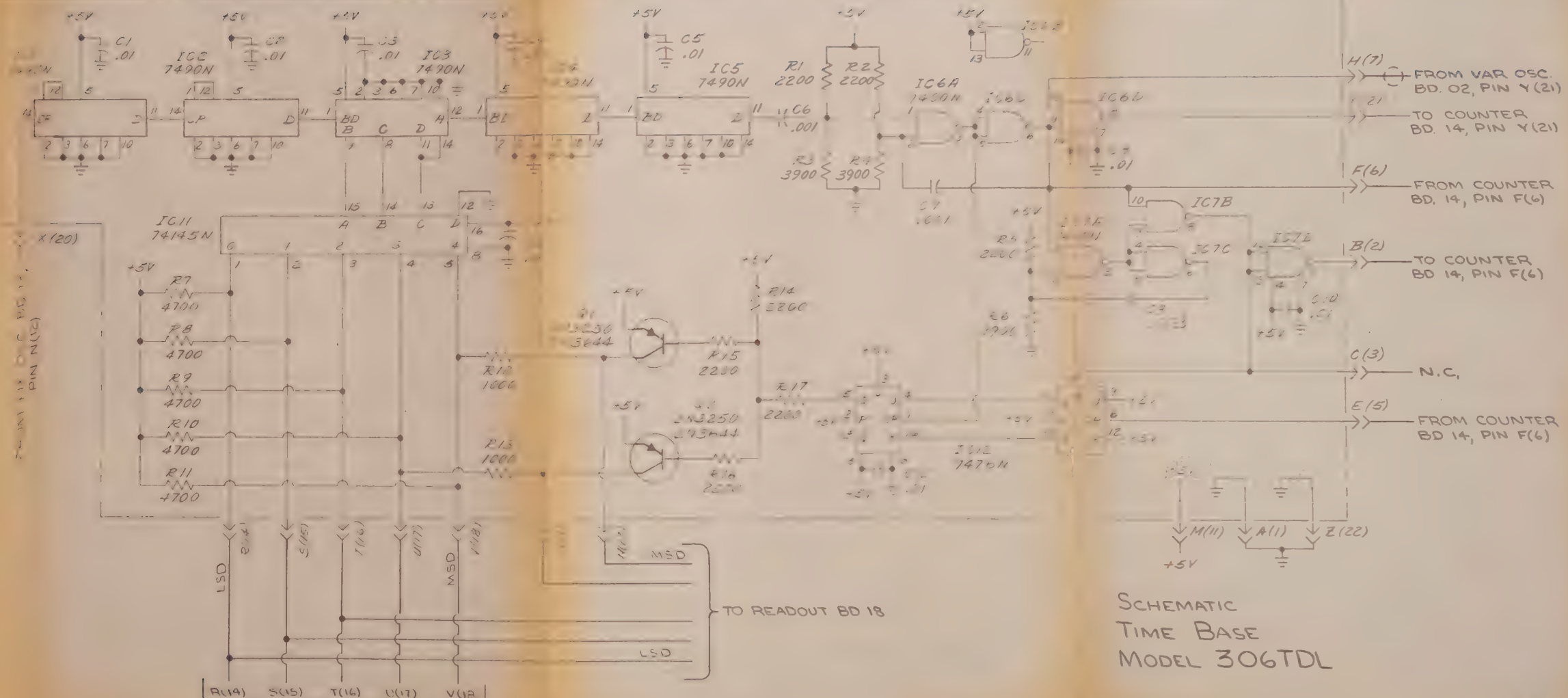
T-8551-A



SCHEMATIC
FIXED OSCILLATOR
AND 2ND MODULATOR
MODEL 306TDL

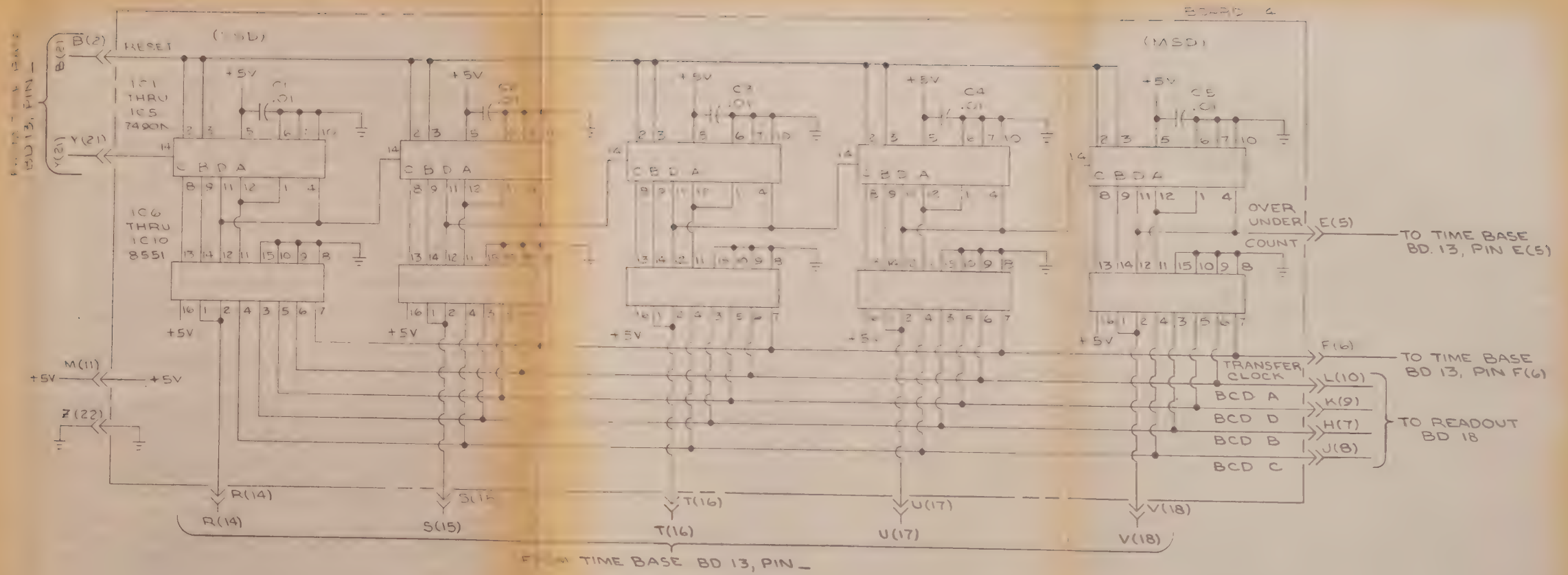
C-8552-A

BOARD 13



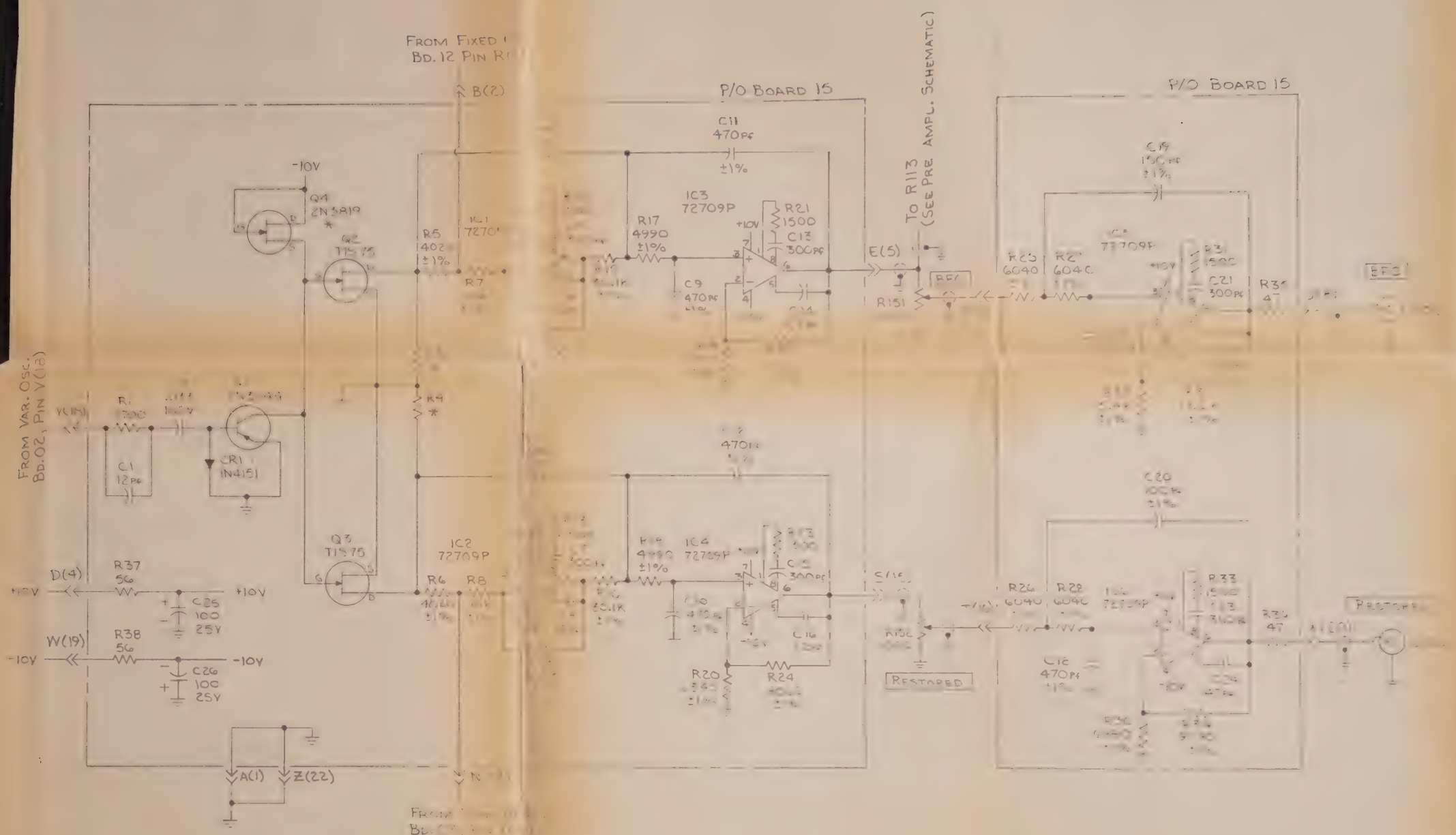
SCHEMATIC
TIME BASE
MODEL 306TDL

T-8553-A



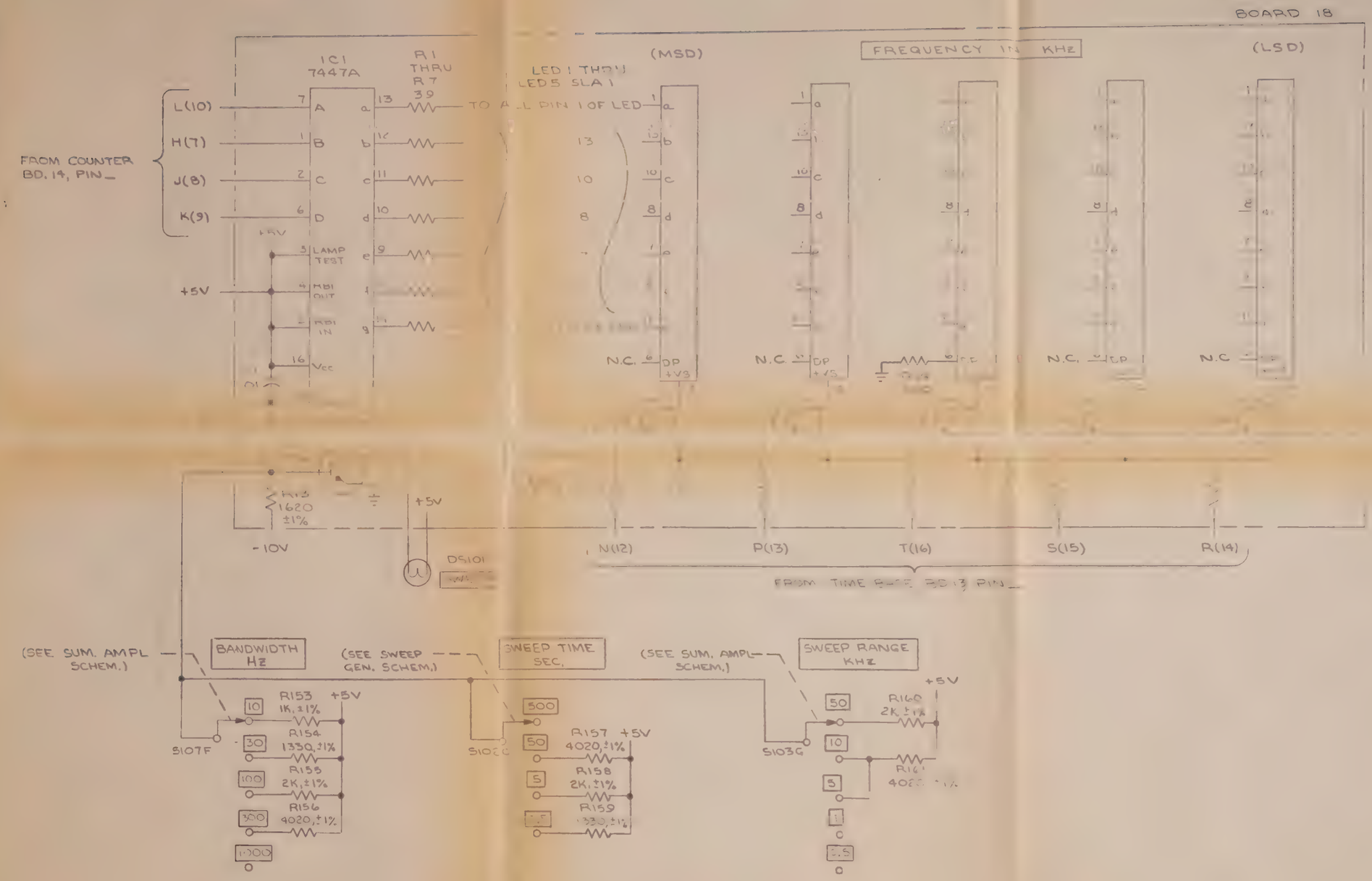
SCHEMATIC
COUNTER AND MULTIPLEXER
MODEL 306TDL

T-8554-A



SCHEMATIC
BFO AND RESTORED
MODEL 30L TDL

C-8585-



SCHEMATIC
READOUT AND
LAMP CIRCUIT
MODEL 306TDL

C-8556-A

IMPORTANT

Notice to the User of this Instrument . . . .
Do you want to be kept up to date on measurement techniques, applications, and new instrumentation? Periodically Scientific-Atlanta, Inc., New Jersey Division publishes technical papers and application notes that may increase the usefulness of your instrumentation.

We will be happy to add your name to this mailing list after receiving the attached prepaid postcard. The information we request will permit us to serve you better, and insure timely delivery of pertinent information.

We suggest the following record be kept for registration, modifications, repairs, etc.

Scientific-Atlanta, Inc.
New Jersey Division

INSTRUMENT RECORD

Manual registered on _ _ _ _ _ _ _ _ _
User's name _ _ _ _ _ _ _ _ _ _ _ _ _ _
Company _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Div./Dept _ _ _ _ _ _ _ _ _ _ _ _ _ _
Street _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
City _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
State/Zip _ _ _ _ _ _ _ _ _ _ _ _ _

Instrument Record:

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Scientific-Atlanta, Inc.
New Jersey Division

INSTRUMENT RECORD (Continued)

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Permit No. 444
DOVER
NEW JERSEY

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FIRST CLASS
Permit No. 444
DOVER
NEW JERSEY

BUSINESS REPLY CARD

No Postage Stamp Necessary if Mailed in The United States

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RANDOLPH PARK WEST,
ROUTE #10,
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